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IS 1890 (Part 12) : 1995
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भारतीय मानक

# मात्राएँ और इकाइयाँ

भाग 12 विशिष्ट संख्याएँ

( पहला पुनरीक्षण )

*Indian Standard*

# QUANTITIES AND UNITS

## PART 12 CHARACTERISTIC NUMBERS

*( First Revision )*

UDC 53.081

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**BUREAU OF INDIAN STANDARDS**
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

*November* 1995 **Price Group 3**

Basic Standards Sectional Committee, MSD 1

## NATIONAL FOREWORD

This Indian Standard (Part 12) (First Revision) which is identical with ISO 31-12 : 1992, issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Basic Standards Sectional Committee (MSD 1) and approval of the Management and Systems Division Council.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

> Comma (,) has been used as a decimal marker while in Indian Standards the current practice is to use a point (.) as the decimal marker.
>
> Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

This standard was first published in 1983. In this revision, following changes have been made:

a) The decision by the International Committee for Weights and Measures (CIPM) in 1980 concerning the status of supplementary units has been incorporated;

b) The title has been changed from Dimensional Parameters to Characterisitc Numbers; and

c) A new clause on tables of quantities and remarks on units,has been included as introduction to the standard.

## ADDITIONAL INFORMATION

IS 1890/ISO 31 consists of the following parts, under the general title 'Quantities and Units':

| *International Standard* | *Corresponding Indian Standard* | *Degree of Equivalence* |
|---|---|---|
| ISO 31-0 : 1992 | IS 1890 (Part 0) : 1995 Quantities and units : Part 0 General principles (*first revision*) | Identical |
| ISO 31-1 : 1992 | IS 1890 (Part 1) : 1995 Quantities and units : Part 1 Space and time (*third revision*) | Identical |
| ISO 31-2 : 1992 | IS 1890 (Part 2) : 1995 Quantities and units : Part 2 Periodic and related phenomena (*second revision*) | Identical |
| ISO 31-3 : 1992 | IS 1890 (Part 3) : 1995 Quantities and units : part 3 Mechanics (*second revision*) | Identical |
| ISO 31-4 : 1992 | IS 1890 (Part 4) : 1982* Quantities, units and symbols : Part 4 Heat (*first revision*) | Technically Equivalent |
| ISO 31-5 : 1992 | IS 1890 (Part 5) : 1995 Quantities and units : Part 5 Electricity and magnetism (*first revision*) | Identical |

(*Continued on third cover*)

# *Indian Standard*
# QUANTITIES AND UNITS
## PART 12 CHARACTERISTIC NUMBERS
## *( First Revision )*

## 1 Scope

This part of ISO 31 gives names and symbols for characteristic numbers used in the description of transport phenomena.

## 2 Characteristic numbers: momentum transport

| Item No. | Symbol | Name | Definition | Remarks |
|---|---|---|---|---|
| 12-1 | $Re$ | Reynolds number | $Re = \frac{\varrho v l}{\eta} = \frac{vl}{\nu}$ | |
| 12-2 | $Eu$ | Euler number | $Eu = \frac{\Delta p}{\varrho v^2}$ | |
| 12-3 | $Fr$ | Froude number | $Fr = \frac{v}{\sqrt{lg}}$ | Sometimes called Reech number. |
| 12-4 | $Gr$ | Grashof number | $Gr = \frac{l^3 g \alpha \Delta T}{\nu^2}$ | $-\frac{\Delta \varrho}{\varrho} = \alpha \Delta T$ |
| 12-5 | $We$ | Weber number | $We = \frac{\varrho v^2 l}{\sigma}$ | |
| 12-6 | $Ma$ | Mach number | $Ma = \frac{v}{c}$ | |
| 12-7 | $Kn$ | Knudsen number | $Kn = \frac{\lambda}{l}$ | |
| 12-8 | $Sr$ | Strouhal number | $Sr = \frac{lf}{v}$ | |

**Symbols used in the definitions in this clause**

| Symbol | Name of quantity | Reference No. in ISO 31 |
|---|---|---|
| $l$ | a characteristic length | 1-3.1 |
| $v$ | a characteristic speed | 1-10 |
| $\Delta T$ | a characteristic temperature difference | 4-1 |
| $\Delta p$ | pressure difference | 3-15.1 |
| $\varrho$ | volumic mass | 3-2 |
| $\eta$ | dynamic viscosity | 3-23 |
| $\nu$ | kinematic viscosity: $\eta/\varrho$ | 3-24 |
| $\sigma$ | surface tension | 3-25 |
| $g$ | acceleration of free fall | 1-11.2 |
| $\alpha$ | cubic expansion coefficient: $(1/V)\ \mathrm{d}V/\mathrm{d}T$ | 4-3.2 |
| $\lambda$ | mean free path | 8-38 |
| $f$ | a characteristic frequency | 2-3.1 |
| $c$ | speed of sound | 7-14.1 |

## 3 Characteristic numbers: transport of heat

| Item No. | Symbol | Name | Definition | Remarks |
|---|---|---|---|---|
| 12-9 | $Fo$ | Fourier number | $Fo = \frac{\lambda t}{c_p \varrho l^2} = \frac{at}{l^2}$ | |
| 12-10 | $Pe$ | Péclet number | $Pe = \frac{\varrho c_p v l}{\lambda} = \frac{vl}{a}$ | $Pe = Re \cdot Pr$ |
| 12-11 | $Ra$ | Rayleigh number | $Ra = \frac{l^3 \varrho^2 c_p g \alpha \Delta T}{\eta \lambda} = \frac{l^3 g \alpha \Delta T}{\nu a}$ | $Ra = Gr \cdot Pr$ |
| 12-12 | $Nu$ | Nusselt number | $Nu = \frac{Kl}{\lambda}$ | The name Biot number, $Bi$, is used when the Nusselt number is reserved for convective transport of heat. |
| 12-13 | $St$ | Stanton number | $St = \frac{K}{\varrho v c_p}$ | $St = Nu/Pe$<br>Sometimes called the Margoulis number, $Ms$.<br>$j = St \cdot Pr^{2/3}$ is called the heat transfer factor. |

**Symbols used in the definitions in this clause**

| Symbol | Name of quantity | Reference No. in ISO 31 |
|---|---|---|
| $l$ | a characteristic length | 1-3.1 |
| $v$ | a characteristic speed | 1-10 |
| $t$ | a characteristic time interval | 1-7 |
| $\Delta T$ | a characteristic temperature difference | 4-1 |
| $g$ | acceleration of free fall | 1-11.2 |
| $\varrho$ | volumic mass | 3-2 |
| $\eta$ | dynamic viscosity | 3-23 |
| $\nu$ | kinematic viscosity: $\eta/\varrho$ | 3-24 |
| $c_p$ | massic heat capacity at constant pressure | 4-16.2 |
| $\alpha$ | cubic expansion coefficient: $(1/V)\,\mathrm{d}V/\mathrm{d}T$ | 4-3.2 |
| $\lambda$ | thermal conductivity | 4-9 |
| $a$ | thermal diffusivity: $\lambda/\varrho c_p$ | 4-14 |
| $K$ | coefficient of heat transfer: heat/(time × cross-sectional area × temperature difference) | 4-10.1 |

## 4 Characteristic numbers: transport of matter in a binary mixture

| Item No. | Symbol | Name | Definition | Remarks |
|---|---|---|---|---|
| 12-14 | $Fo^*$ | Fourier number for mass transfer | $Fo^* = \frac{Dt}{l^2}$ | $Fo^* = Fo/Le$<br>Compare item 12-9. |
| 12-15 | $Pe^*$ | Péclet number for mass transfer | $Pe^* = \frac{vl}{D}$ | $Pe^* = Re \cdot Sc = Pe \cdot Le$<br>Compare item 12-10. |
| 12-16 | $Gr^*$ | Grashof number for mass transfer | $Gr^* = \frac{l^3 g \beta \Delta x}{\nu^2}$ | Compare item 12-4.<br>$-\frac{\Delta \varrho}{\varrho} = \alpha \Delta T + \beta \Delta x$ |
| 12-17 | $Nu^*$ | Nusselt number for mass transfer | $Nu^* = \frac{kl}{\varrho D}$ | Sometimes called the Sherwood number, *Sh*.<br>Compare item 12-12. |
| 12-18 | $St^*$ | Stanton number for mass transfer | $St^* = \frac{k}{\varrho v}$ | $St^* = Nu^*/Pe^*$<br>Compare item 12-13.<br>$j_m = St^* \cdot Sc^{2/3}$ is called the mass transfer factor. |

**Symbols used in the definitions in this clause**

| Symbol | Name of quantity | Reference No. in ISO 31 |
|---|---|---|
| $l$ | a characteristic length | 1-3.1 |
| $v$ | a characteristic speed | 1-10 |
| $t$ | a characteristic time interval | 1-7 |
| $\Delta T$ | a characteristic temperature difference | 4-1 |
| $\Delta x$ | a characteristic difference in mole fraction | 8-14.1 |
| $g$ | acceleration of free fall | 1-11.2 |
| $\varrho$ | volumic mass | 3-2 |
| $\nu$ | kinematic viscosity: $\eta/\varrho$ | 3-24 |
| $\beta$ | $\beta = -(1/\varrho)(\partial \varrho/\partial x)_{T,p}$ | — |
| $D$ | diffusion coefficient | 8-39 |
| $k$ | mass transfer coefficient: mass/(time × cross-sectional area × mole-fraction difference) | — |
| $\alpha$ | cubic expansion coefficient: $(1/V)\, \mathrm{d}V/\mathrm{d}T$ | 4-3.2 |

## 5 Characteristic numbers: constants of matter

| Item No. | Symbol | Name | Definitions | Remarks |
|---|---|---|---|---|
| 12-19 | $Pr$ | Prandtl number | $Pr = \frac{\eta c_p}{\lambda} = \frac{\nu}{a}$ | |
| 12-20 | $Sc$ | Schmidt number | $Sc = \frac{\eta}{\varrho D} = \frac{\nu}{D}$ | |
| 12-21 | $Le$ | Lewis number | $Le = \frac{\lambda}{\varrho c_p D} = \frac{a}{D}$ | $Le = Sc/Pr$ |

**Symbols used in the definitions in this clause**

| Symbol | Name of quantity | Reference No. in ISO 31 |
|---|---|---|
| $\varrho$ | volumic mass | 3-2 |
| $\eta$ | dynamic viscosity | 3-23 |
| $\nu$ | kinematic viscosity: $\eta/\varrho$ | 3-24 |
| $D$ | diffusion coefficient | 8-39 |
| $c_p$ | massic heat capacity at constant pressure | 4-16.2 |
| $\lambda$ | thermal conductivity | 4-9 |
| $a$ | thermal diffusivity: $\lambda/\varrho c_p$ | 4-14 |

## 6 Characteristic numbers: magnetohydrodynamics

| Item No. | Symbol | Name | Definition | Remarks |
|---|---|---|---|---|
| 12-22 | $Rm$ | magnetic Reynolds number | $Rm = \frac{vl}{1/\mu\sigma} = v\mu\sigma l$ | |
| 12-23 | $Al$ | Alfvén number | $Al = \frac{v}{B/(\varrho\mu)^{1/2}} = \frac{v}{v_\mathrm{A}}$ | $v_\mathrm{A} = B/(\varrho\mu)^{1/2}$ is called the Alfvén speed. |
| 12-24 | $Ha$ | Hartmann number | $Ha = Bl\left(\frac{\sigma}{\varrho\nu}\right)^{1/2}$ | |
| 12-25 | $Co$ | Cowling number | $Co = \frac{B^2}{\mu\varrho v^2}$ | $Co = (v_\mathrm{A}/v)^2 = Al^{-2}$<br>Often called the "second" Cowling number, $Co_2$.<br>The "first" Cowling number is often defined as<br>$Co_1 = Ha^2/Re = \frac{B^2 l\sigma}{\varrho v} = Co \cdot Rm$ |

**Symbols used in the definitions in this clause**

| Symbol | Name of quantity | Reference No. in ISO 31 |
|---|---|---|
| $\varrho$ | volumic mass | 3-2 |
| $l$ | a characteristic length | 1-3.1 |
| $v$ | a characteristic speed | 1-10 |
| $\nu$ | kinematic viscosity: $\eta/\varrho$ | 3-24 |
| $\mu$ | magnetic permeability | 5-24.1 |
| $B$ | magnetic flux density | 5-19 |
| $\sigma$ | electrical conductivity | 5-37 |

*(Continued from second cover)*

| *International Standard* | *Corresponding Indian Standard* | *Degree of Equivalence* |
|---|---|---|
| ISO 31-6 : 1992 | IS 1890 (Part 6) : 1983* Quantities, units and symbols : Part 6 Light and related electromagnetic radiations | Technically Equivalent |
| ISO 31-7 : 1992 | IS 1890 (Part 7) : 1995 Quantities and units : Part 7 Acoustics (*first revision*) | Identical |
| ISO 31-8 : 1992 | IS 1890 (Part 8) : 1995 Quantities and units : Part 8 Physical chemistry and molecular physics (*first revision*) | Identical |
| ISO 31-9 : 1992 | IS 1890 (Part 9) : 1995 Quantities and units : Part 9 Atomic and nuclear physics (*first revision*) | Identical |
| ISO 31-10 : 1992 | IS 1890 (Part 10) : 1995 Quantities and units : Part 10 Nuclear reactions and ionizing radiation (*first revision*) | Identical |
| ISO 31-11 : 1992 | IS 1890 (Part 11) : 1995 Quantities and units : Part 11 Mathematical signs and symbols for use in the physical science and technology (*second revision*) | Identical |
| ISO 31-12 : 1992 | IS 1890 (Part 12) : 1995 Quantities and units: Part 12 Characteristic numbers (*first revision*) | Identical |
| ISO 31-13 : 1992 | IS 1890 (Part 13) : 1983* Quantities, units and symbols : Part 13 Solid state physics | Technically Equivalent |

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* Under revision

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| Amend No. | Date of Issue | Text Affected |
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